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SEARCH REQUEST FORM

Scientific and Technical Information Center

Requester's Full Name: MARK RADEMACHER Examiner # : 78447 Date: 26 August 2003
Art Unit: 3761 Phone Number 30 ______ Serial Number: 09/765681
Mail Box and Bldg/Room Location: 3E12 Results Format Preferred (circle): PAPER DISK E-MAIL

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Please provide a detailed statement of the search topic, and describe as specifically as possible the subject matter to be searched. Include the elected species or structures, keywords, synonyms, acronyms, and registry numbers, and combine with the concept or utility of the invention. Define any terms that may have a special meaning. Give examples or relevant citations, authors, etc, if known. Please attach a copy of the cover sheet, pertinent claims, and abstract.

Title of Invention: AUTO CPAP

Inventors (please provide full names): OVE ECKLUND HENRIK BERGFALK

Earliest Priority Filing Date: 10/2/2000

**For Sequence Searches Only* Please include all pertinent information (parent, child, divisional, or issued patent numbers) along with the appropriate serial number.*

Method for sleep disordered breathing (e.g. apnea; apneaic breathing) using an artificial neural network.

Controlling continuous positive airway pressure in response to the neural network.

- The neural network uses cepstrum data/coeff
- The neural network is a Kohonen type neu

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STAFF USE ONLY	Type of Search	Vendors and cost where applicable
Searcher: Jeanne Harrigan	NA Sequence (#) ______	STN ______
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PTO-1590 (8-01)

STIC Search Report
EIC 3700

USPTO

STIC Database Tracking Number: 102427

TO: Mark Rademacher Location: CP2, 3E12 Art Unit: 3761 Case Serial Number: 09/965681	From: Jeanne Horrigan Location: EIC 3700 CP2-2C08 Phone: 305-5934 jeanne.horrigan@uspto.gov

Search Notes

Attached are the search results for the Auto CPAP, including author and prior art searches in foreign and international patent databases, and medical and general sci/tech information in non-patent literature databases and on the Internet using the Scirus search engine.

I found a lot of references that looked good; I tagged The ones I thought looked best to me, but I suggest you review all of the references.

Also attached is a search feedback form. Completion of the form is voluntary. Your completing this form would help us improve our search services.

I hope the attached information is useful. Please feel free to contact me (phone 305-5934 or email jeanne.horrigan@uspto.gov) if you have any questions or need additional searching on this application.

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Date 8 / 26 / 03

Serial Number of Application 09/965681

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Number of Results returned (Minimum 50/ Maximum 300) 150

Keywords to emphasize

cepstrum, cestral

neural network

Kohonen

Auto CPAP

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of Swedish patent application No. SE 0003531-1 which was filed on October 2, 2000 and is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to method and an apparatus for the detection and treatment of disordered breathing during sleep, in particular to a method and apparatus employing an artificial neural network.

BACKGROUND OF THE INVENTION

U.S. Patent No. 5,953,713 (Behbehani et al.), incorporated herein by reference, discloses a method for treating sleep disordered breathing comprising measuring a respiration-related variable at an interface placed over a patient's airway coupled to a pressurized gas, feeding cepstrum data obtained from the respiration related variable(s) into an artificial neural network trained to recognize patterns characterizing sleep disordered breathing; supplying pressurized gas to the patients airway in response to recognition of the artificial neural network of sleep disordered breathing. The sampling frequency of the pressure transducer's output disclosed in the preferred embodiment is 512 Hz. A Fourier transform is calculated every 1/16 second using a 32 sample values window.

Another aspect of frequency analysis is that, on the one hand, the precision is proportional to the number of input data but that, on the

other hand, the response time is correspondingly increased. While high precision is welcome since rather small changes in breath pattern can be detected, a slower response increases the risk of progressive deterioration of the airway aperture, and thereby more severe respiratory disturbance before the patient is aroused. Other methods of detecting sleep disorder are based on breath-by-breath analysis

Alternatively, if adequate treatment is not installed, the patient will be aroused in a more extended time perspective.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide an improved method for automatically supplying continuous positive airways pressure to a patient

It is another object of the present invention to provide an automatic continuous positive airways pressure apparatus (ACPAP) which lacks at least some of the drawbacks of state-of-the-art apparatus.

Additional objects of the invention are evident from the following short description of the invention, the attached drawings illustrating a preferred embodiment, the detailed description thereof, and the appended claims.

SUMMARY OF THE INVENTION

The present invention is based on the insight that a direct analysis of the flow signal is more specific than an analysis of disordered breath, in particular flow limited breath, based on frequency analysis.

According to the present invention is provided an automatic continuous positive airways pressure apparatus (ACPAP) in which the air flow from a CPAP or other system providing positive air pressure to a patient is measured for calculation of a number of parameters specific to the signal. The set of parameters comprises cepstrum coefficients and energy content, and is selected to indicate an apneic event of breathing during sleep, such as apnea, hypoapnea, and flow limitation. Data for these parameters collected from a large number of patients were used to train an artificial neural network to teach the system the variation ranges of the parameters for subsets of patients under a number of circumstances. The result from the artificial neural network is obtained as a low-dimensional grid of nodes in which each respiration type is represented by trajectory or a subsets of nodes. A trajectory for a normal breath looks very different from that of a breath during disturbed sleep.

If breathes symptomatic of a condition of disturbed sleep are detected the CPAP pressure is increased. In contrast, CPAP pressure is reduced in a normal condition.

Thus, according to the present invention is disclosed a method for the detection and treatment of disordered breathing during sleep employing an artificial neural network in which data related to breathing gas flow are analyzed in an artificial neural network.

Specifically, a method according to an embodiment of the present invention comprises the following steps:

placing a mask with a tube over a patient's airway, the mask being in communication with a source of a pressurized breathing gas controlled by a CPAP, thereby establishing a respiratory circuit;

periodically sampling the gas flow in the circuit;

periodically calculating values for one or several parameters distinctive of a breathing pattern;

periodically feeding the parameter values to an artificial neural network trained to recognize breathing patterns characteristic of sleep disordered breathing;

analyzing the parameter values in the neural network;

controlling pressurized breathing gas supply in response to the output from the neural network.

It is preferred to feed said parameter values to the network at a frequency of from 2 Hz to 30 Hz, preferably of about 20 Hz. It is preferred for said parameters to comprise cepstrum coefficients and energy slope.

According to a first preferred aspect of the invention the artificial neural network is trained with data collected from a large number of patients. The data will have been collected from patients differing in many aspects: sex, age, body weight, breath pattern, etc. In addition, variants of sleep disordered breathing such as those occurring preferentially in the back position, those occurring during particular stages of sleep, and those occurring under the influence of drugs or alcohol need to be addressed.

Such data are advantageously collected in sleep laboratories in which the state of sleep is followed as well as the type and severity of the breathing disturbance is monitored by use of a polysomnography system. The collected data form a primary database. During the training of the artificial neural network the data is quantified under formation of a small secondary dedicated database which can be stored in a ACPAP. Thus, according to the present invention, a

dedicated secondary database obtained from a primary database comprising data collected from a large number of persons is stored in the ACPAP.

According to a second aspect of the invention it is preferred to periodically sample the gas flow during breathing.

The ANN comprises a number of nodes representing sets of training data. Each node reflects a state or an incident (feature). Neighboring nodes represent incidents of small geometric distance. In the same way as in training an incident vector is extracted for each flow data sample. The Euclidean distance from the incident vector to each node is calculated. The node in closest proximity to the vector is associated with it. Sequences of incident vectors are followed as sequences of nodes in the artificial neural network. It can be said that a sequence of nodes is the response of the network. Thus a trajectory in the geometric structure of the network (response) is followed rather than in the parameter space. The fact that the dimension of the network most often is smaller than the parameter space is of advantage since calculation thereby is simplified. The response from the network forms the basis for distinguishing between apnea, hypoapnea and a normal breathing state and thus, for CPAP pressure control.

The invention thus is based on the use of an artificial neural network (ANN) of Kohonen-map type (associative memory; T. Kohonen, Self-Organization and Associative Memory, 2nd Ed., Springer Verl., Berlin 1987) for detecting apnea or apnea-like episodes. The ANN is trained with data obtained from a number of patients in a sleep laboratory. The readily trained ANN forms a global (universal) structure of data stored in a non-volatile memory in an ACPAP. In use the breathing pattern of a patient forms trajectories (traces) in the ANN. A normal

breathing cycle forms a closed trajectory. A trajectory deviating from normal is indicative of a breath disturbance. The ANN is structured in way so as to make certain areas represent initial stages of apnea. The passage of a trajectory through such an area or touching its border indicates that the amount of air provided to the patient should be increased so as to re-establish normal breathing. Once breathing has been normalized the adduced amount of air is reduced to normal, i.e., to the pre-established base value.

The artificial neural network is trained in two phases described in P. Brauer and P. Knagenhjelm, Infrastructure in Kohonen Maps, Proc. IEEE ICASSP, Glasgow 1989.

The purpose of the analysis is to extract, from the series of air flow rate measurements, values of the parameters chosen to classify and detect apneic and hypoapneic states. In each single analysis the parameters are made to form an incident or feature vector on which all training and decision-making is based. All sample values are individually analyzed in preparation for a quick response to changes in flow which are typical forewarnings of an apneic or hypoapneic state.

According to a third preferred aspect of the invention linear predictive coding is used to analyze the parameter values fed to the neural network. A linear predictive coding analysis comprising four parameters is carried out for all samples. In particular, the so-called A-parameters from the analysis are converted to cepstrum parameters for optimal correlation between parameter distance and conceptual distance, that is, so-called associativity.

According to a fourth preferred aspect of the invention the prediction error in calculating linear predictive coding is used as a basis for the parameter next in line. The error is filtered to counteract short-term variations and normalized with the total energy of the analytical window.

For calculations of energy a larger window than for the linear predictive coding analysis is used. The energy of the latest windows can be used to calculate a line the inclination which describes a trend. The difference in trend is used as a further parameter. Thus, according to a fifth preferred aspect of the invention, the inclination of a trend line calculated from measurements and is used as a parameter.

According to the present invention is also disclosed an apparatus for the detection and treatment of disordered breathing during sleep for use with a CPAP, the apparatus including a probe for sampling breathing air flow data, in particular on inhalation, and an artificial neural network for analyzing, directly or indirectly, said data to control breathing air pressure.

According to the present invention is also disclosed a CAPAP comprising a probe for sampling breathing air flow data, in particular on inhalation, and an artificial neural network for analyzing, directly or indirectly, said data to control breathing air pressure.

Further variations of the present invention are disclosed in the following detailed description of a preferred embodiment thereof illustrated in a drawing.